CLAIMS

What is claimed is:

1. A method of annealing a metal layer on a substrate in a chamber, comprising:

positioning a substrate having a metal layer thereon in the chamber;

removing atmospheric gases from the chamber;

providing process gas to the chamber; and

annealing the metal layer at a temperature greater than about 80 degrees Celsius.

2. The method of claim 1 wherein the annealing the metal layer is performed at a temperature within a range of about 80 degrees Celsius to about 400 degrees Celsius.

3. The method of claim 1, wherein removing gases comprises pumping the chamber to a pressure less than about 5 torr.

4. The method of claim 3 wherein the pumping step has a duration in the range of about 3 seconds to about 5 seconds.

5. The method of claim 1, wherein providing the process gas comprises providing one or more gases selected from the group consisting of nitrogen, hydrogen, argon, helium, and combinations thereof.

6. The method of claim 1 wherein the process gas has a concentration of hydrogen in the range of about 2.5% to about 4.5%.

7. The method of claim 1 wherein the process gas is provided to the chamber at a flow rate in the range of about 0.2 slm to about 0.6 slm per liter of chamber volume.

8. The method of claim 1 wherein step (d) has a duration in the range of about 15 seconds to about 180 seconds.

9. The method of claim 1 wherein the process gas is provided to the chamber during at least a portion of the annealing step.

10. The method of claim 1 wherein the metal layer comprises copper.

11. The method of claim 1 further comprising cooling the metal layer to a temperature in the range of about 50 degrees Celsius to about 100 degrees Celsius within a period of about 30 seconds.

12. The method of claim 11 wherein the pressure of the process gas in the chamber during the annealing step is in the range of about 100 torr to about 150 torr.

13. The method of claim 11 wherein the cooling step comprises bringing the substrate into the proximity of a cold plate.

14. The method of claim 1, wherein the metal layer is deposited by electroplating.

15. A method of annealing a copper layer in a chamber, comprising:

a) positioning a substrate having a copper layer thereon in the chamber;

b) pumping the chamber to a pressure less than about 5 torr;

c) providing process gas to the chamber at a flow rate less than about 0.6 slm per liter of chamber;

d) annealing the copper layer at a temperature greater than about 80 degrees Celsius for a duration of about 15 seconds to about 180 seconds; and

e) reducing the temperature of the copper layer to a temperature in the range of about 50 degrees Celsius to about 100 degrees Celsius within a period of about 30 seconds.

16. The method of claim 15 wherein the process gas is selected from the group consisting of nitrogen, hydrogen, argon, helium, and combinations thereof.

17. The method of claim 15 wherein the process gas in step (c) is provided to the chamber at a flow rate in the range of about 0.4 slm per liter of chamber to about 0.6 slm per liter of chamber.

18. The method of claim 15 wherein the annealing of step (d) is performed at a temperature in the range of about 80 degrees Celsius to about 400 Celsius for a duration in the range of about 15 seconds to about 180 seconds.

19. The method of claim 15 wherein the temperature of the copper layer in step (e) is reduced to a temperature of about 60 Celsius to about 80 Celsius within a period of about 30 seconds.

20. A method of forming a feature on a substrate, comprising:

a) depositing a dielectric layer on the substrate;

b) forming at least one feature in the dielectric layer;

c) depositing a metal layer in the at least one feature;

d) positioning the substrate in an annealing chamber;

e) removing atmospheric gases from the annealing chamber;

f) providing process gas to the annealing chamber; and

g) annealing the metal layer at a temperature greater than about 80 degrees Celsius.

21. The method of claim 20 wherein step (g) is performed at a temperature between about 80 degrees Celsius and about 400 degrees Celsius.

22. The method of claim 20, wherein step (e) comprises pumping the chamber to pressure less than about 5 torr.

23. The method of claim 22 wherein the pumping of step (e) has a duration of about 3 seconds to about 5 seconds.

24. The method of claim 20, wherein the process gas of step (f) comprises one or more gases selected from the group consisting of nitrogen, hydrogen, argon, helium, and combinations thereof.

25. The method of claim 20 wherein the process gas has a concentration of hydrogen in the range of about 2.5% to about 4.5%.

26. The method of claim 20 wherein the process gas is provided to the chamber at a flow rate of about 2 slm to about 6 slm.

27. The method of claim 20 wherein step (g) has a duration of about 15 seconds to about 180 seconds.

28. The method of claim 20 wherein the process gas of step (f) is provided to the chamber during at least a portion of step (g).

29. The method of claim 20 wherein the metal layer comprises copper.

30. The method of claim 20 further comprising:

(h) cooling the metal layer to a temperature in the range of about 50 degrees Celsius to about 100 degrees Celsius within a period of about 30 seconds.

31. The method of claim 30 wherein the pressure of the process gas in the chamber during step (h) is in the range of about 100 torr to about 150 torr.

32. The method of claim 30 wherein step (h) comprises bringing the substrate into the proximity of a cold plate.

33. The method of claim 20, wherein the metal layer is deposited by electroplating.

34. The method of claim 20, further comprising the step of

(i) planarizing the metal layer.

35. A method of forming a feature on a substrate, comprising:

a) depositing a dielectric layer on the substrate;

b) forming at least one feature in the dielectric layer;

c) depositing a copper layer in the at least one feature;

d) positioning the substrate in an annealing chamber;

e) pumping the annealing chamber to a pressure less than about 5 torr;

f) providing process gas to the annealing chamber at a flow less than about 0.6 slm per volumetric liter of the annealing chamber;

g) annealing the copper layer at a temperature greater than about 80 degrees Celsius for a duration of about 15 seconds to about 180 seconds; and

h) reducing the temperature of the copper layer to a temperature of about 50 degrees Celsius to about 100 degrees Celsius within a period of about 30 seconds.

36. The method of claim 35 wherein the process gas is selected from the group consisting of nitrogen, hydrogen, argon, helium, and combinations thereof.

37. The method of claim 35 wherein the process gas in step (f) is provided to the chamber at a flow rate in the range of about 0.4 slm per liter of chamber to about 0.6 slm per liter of chamber.

38. The method of claim 35 wherein the annealing of step (g) is performed at a temperature of about 80 degrees Celsius to about 400 Celsius for a duration of about 15 seconds to about 180 seconds.

39 The method of claim 35 wherein the temperature of the copper layer is reduced to a temperature in the range of about 60 Celsius to about 80 Celsius within a period of about 30 seconds.

40. A computer storage medium containing a software routine that, when executed, causes a general purpose computer to control a deposition chamber using a layer deposition method, comprising:

a) positioning a substrate having a metal layer thereon in the chamber;

b) removing atmospheric gases from the chamber;

c) providing process gas to the chamber; and

d) annealing the metal layer at a temperature greater than about 80 degees Celsius.

41. The computer storage medium of claim 40 wherein the annealing of step (d) is performed at a temperature within a range of about 80 degrees Celsius to about 400 degrees Celsius.

42. The computer storage medium of claim 40, wherein step (b) comprises pumping the chamber to pressure less than about 5 torr.

43. The computer storage medium of claim 42 wherein the pumping of step (b) has a duration in the range of about 3 seconds to about 5 seconds.

44. The computer storage medium of claim 40, wherein the process gas of step (c) comprises one or more gases selected from the group consisting of nitrogen, hydrogen, argon, helium, and combinations thereof.

45. The computer storage medium of claim 40 wherein the process gas has a concentration of hydrogen in the range of about 2.5% to about 4.5%.

46. The computer storage medium of claim 40 wherein the process gas is provided to the chamber at a flow rate in the range of about 2 slm to about 6 slm.

47 The computer storage medium of claim 40 wherein step (d) has a duration in the range of about 15 seconds to about 180 seconds.

48. The computer storage medium of claim 40 wherein the process gas of step (c) is provided to the chamber during at least a portion of step (d).

49. The computer storage medium of claim 40 wherein the metal layer comprises copper.

50. The computer storage medium of claim 40 wherein the layer deposition method further comprises:

(e) cooling the metal layer to a temperature in the range of about 50 degrees Celsius to about 100 degrees Celsius for a duration of 30 seconds.

51. The computer storage medium of claim 50 wherein the pressure of the process gas in the chamber is in the range of about 100 torr to about 150 torr.

52. The computer storage medium of claim 50 wherein step (e) comprises bringing the substrate into the proximity of a cold plate.

53. The computer storage medium of claim 40, wherein the metal layer is deposited by electroplating.

54. A computer storage medium containing a software routine that, when executed, causes a general purpose computer to control a deposition chamber using a layer deposition method, comprising:

a) positioning a substrate having a copper layer thereon in the chamber;

b) pumping the chamber to a pressure less than about 5 torr;

c) providing process gas to the chamber at a flow rate less than about 0.6 slm per liter of chamber;

d) annealing the copper layer at a temperature greater than about 80 degrees Celsius for a duration in the range of about 15 seconds to about 180 seconds; and

e) reducing the temperature of the copper layer to a temperature in the range of about 50 degrees Celsius to about 100 degrees Celsius within a period of about 30 seconds.

55. The computer storage medium of claim 54 wherein the process gas is selected from the group consisting of nitrogen, hydrogen, argon, helium, and combinations thereof.

56. The computer storage medium of claim 54 wherein the process gas in step (c) is provided to the chamber at a flow rate in the range of about 0.4 slm per liter of chamber to about 0.6 slm per liter of chamber.

57. The computer storage medium of claim 54 wherein the annealing of step (d) is performed at a temperature in the range of about 80 degrees Celsius to about 400 Celsius for a duration in the range of about 15 seconds to about 180 seconds.

58. The computer storage medium of claim 54 wherein the temperature of the copper layer is reduced to a temperature in the range of about 60 Celsius to about 80 Celsius within a period of about 30 seconds.

59. A method for annealing a copper layer deposited at least partially via an electrochemical plating process, comprising:

substantially removing atmospheric gases from an annealing chamber having a substrate positioned therein, the substrate having the copper layer deposited thereon;

flowing a non-oxidizing process gas to the annealing chamber at a flow rate of less than about 0.6 slm; and

annealing the substrate at a temperature greater than about 80° Celsius for more than about 15 seconds and less than about 3 minutes.

60. The method of claim 59, further comprising cooling the substrate to a temperature range of between about 60° Celsius and about 80° Celsius within a period of about 30 seconds.

61. The method of claim 59, wherein the non-oxidizing process gas is supplied to the annealing chamber and provides a pressure in the range of about 100 torr to about 150 torr.

62. The method of claim 59, wherein substantially removing atmospheric gases comprises pumping the annealing chamber to about 5 torr.